



Response of Cowpea (*Vigna unguiculata* L. Walp) to Time of Application and Nitrogen Fertilizer on the Degraded Soil of Southern Guinea Savanna Zone of Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author EN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EN and UDF managed the analyses of the study. Author UDF managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ASRJ/2020/v3i130066

Editor(s):

- (1) Dr. Santosh Kumar, University of Missouri, Columbia.
(2) Dr. Alessandro Buccolieri, Università del Salento, Italy.

Reviewers:

- (1) Isa Musa Mabu, Yobe State University, Nigeria.
(2) Paul Kweku Tandoh, Kwame Nkrumah University of Science and Technology, Ghana.
Complete Peer review History: <http://www.sdiarticle4.com/review-history/55649>

Original Research Article

Received 12 January 2020
Accepted 19 March 2020
Published 27 March 2020

ABSTRACT

Field trials were conducted during 2017 and 2018 rainy season, to investigate the effect of nitrogen fertilizer rates and time of application on the growth and yield of cowpea. The treatment consisted of three levels of urea: 0, 40, 80 kg N ha⁻¹ and the times of fertilizer application: during planting of cowpea, 2 weeks after planting, 4 weeks after planting and 6 weeks after planting; which were factorially combined to form twelve treatments and laid in Randomized Complete Block Design (RCBD). The results showed that, Nitrogen fertilizer rates and time of application had a significant increased on all the growth and yield parameters of cowpea in both years of trials. Application of 80 kg N ha⁻¹ produced the highest number of cowpea leaves (134.45 and 139.23), number of branches (9.45 and 10.54), vine length (78.23cm and 80.12cm) and highest seed weight of 0.52 t ha⁻¹ in both 2017 and 2018 trials. However, the control plots produced plants with the highest number of root

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nodules (14.78 and 12.49) in both years of cropping. Also, application of nitrogen fertilizer at two weeks after planting of cowpea produced the highest growth and seed weight of 0.68 t ha^{-1} in 2017 cropping; while in 2018 trial, application of nitrogen fertilizer at two weeks after cowpea planting produced seed yield of 0.69 t ha^{-1} which is statistically similar with application of nitrogen fertilizer on the fourth week after planting which produced 0.55 t ha^{-1} of cowpea seeds. The interaction between nitrogen fertilizer application rates and time of application did not showed any significant difference in cowpea yield and yield components in both years of cropping.

Keywords: Response; cowpea; nitrogen; time; fertilizer.

1. INTRODUCTION

Cowpea *Vigna unguiculata* L. Walp is an important tropical food grain legume for man and livestock in the dry savanna zone of the tropics. According to FAOSTAT [1] and the Brazilian National Supply Company [2], the ten world producers of dry cowpeas in 2016 were Nigeria (3,028,000 MT), Niger (987,000 MT), Brazil (713,000 MT), Burkina Faso (603,000 MT), Cameroon (191,000 MT), Tanzania (187,000 MT), Sudan (165,000 MT), Kenya (147,000 MT), Mali (146,000 MT), and then Myanmar (113,000 MT) from the Asia region. The ability of cowpea to tolerate drought and poor soil makes it an important crop in the savannah region of Nigeria, where these constraints restrict the cultivation of other crops. Cowpea seed is nutritious and is a cheap source of protein for both rural and urban consumers. The seed contains about 25% protein and 64% carbohydrate [3]. Despite the high level of cowpea production in Nigeria, yields of cowpea are low compared with other parts of the world [4]. This may be due to low soil fertility as soils in the tropical savanna are deficient in plant nutrients especially nitrogen and phosphorus [5]. Nwajiuba and Akinsanmi [6] have earlier reported the problem of declining soil fertility in crop-based farming system of sub-Saharan Africa. Most of the soils in southern guinea savanna region of Nigeria are strongly weathered and dominated by low-activity clay minerals which have low nutrient status. Therefore, these soils cannot supply the quantities of nutrients required such that crop yield levels can rise rapidly once cropping commences. Soil nutrients deficiency especially nitrogen, phosphorus and potassium in soils of southern Nasarawa state has earlier been reported by Ndor [7]. Most of the poor and peasant farmers that are involved in growing cowpea in the southern guinea savanna zone of Nigeria; cultivate cowpea on marginal or nutrients depleted soils and do not applied fertilizer on the crop. This may be attributed to the fact that farmers believed that cowpea have the capacity to fixed nitrogen into the soil through

biological nitrogen fixation (BNF) mechanism. Therefore, does not need any form of nitrogenous fertilizer. Also, the high cost of inorganic fertilizers makes them uneconomical and out of reach of the poor peasant farmers who still dominate the agricultural landscape of Nigeria. Cowpea that depends solely on symbiotically fixed nitrogen may well suffer from temporary N deficiency during seedling growth once the cotyledon reserves have been exhausted. Therefore, cowpea may require nitrogen before the onset of symbiotic nitrogen fixation; when cotyledonary nitrogen reserves are exhausted. It has been recognized and demonstrated that the application of a small amount of nitrogen fertilizer as starter fertilizer, enhances early vegetative growth [8]. Nitrogen has a stimulating effect on root activity and rooting pattern of the cowpea, and that available nitrogenous compounds allowed seedlings to make a good start before nitrogen fixation. Sarr et al. [9], have shown that plants given inorganic nitrogen during early vegetative growth were much larger by the onset of flowering than those dependent on symbiotic nitrogen fixation alone and such plants also produced more branches and peduncles resulting in greater number of pods, seeds and significantly higher yields. Many authors have reported significant effect of N fertilization on yield of cowpea across many ecological zones of Nigeria [10,11,4,5]. However, there is dearth of documented information on appropriate timing of application of this nitrogen fertilizer for optimal cowpea yield. Therefore, the objective of this study is to report the appropriate time of nitrogen fertilizer application on growth and yield of cowpea in southern guinea savanna zone of Nigeria.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was carried out at the teaching and research farm, College of Agriculture, Lafia, Nasarawa State, Nigeria during the wet season

of 2017 and 2018. The study area falls within the Guinea savanna zone of North of central Nigeria and is located between Latitude 08.33 N and Longitude 08.32 E. Rainfall usually starts from May – October and the average monthly rainfall ranged from 40 mm-350 mm. The months of July and August usually records heavy rainfall. The daily maximum temperature ranged from 20.0°C – 38.5°C and daily minimum ranged between 18.7°C – 28.2°C. The months of February to early April are the months that have the highest maximum temperature, while the lowest maximum temperature months were recorded in December and January because of the prevailing cold harmattan wind from the northern part of the country at this period. The relative humidity rises as from April to a maximum of about 75-90 percent in July [12].

2.2.1 Climate

The study area falls within southern guinea savanna agroecological zone of Nigeria. Rainfall period is usually from March – October and the average monthly rainfall figures range from 40 mm-350 mm. The months of July and August usually record heavy rainfall. The daily maximum temperature ranges from 20.0°C–38.5°C and daily minimum ranges between 18.7°C–28.2°C. The months of February to early April are the months that have the highest maximum temperature while the lowest maximum temperature are recorded in December and January because of the prevailing cold harmattan wind from the northern part of the country at this period. The relative humidity rises from April to a maximum of about 75- 90 percent in July [12].

2.2.2 Soil

The soil type of the study area is composed of highly leached alfisols with high base saturation. The soil is strongly acidic and has high content of iron and aluminium oxides hence reddish brown in colour with very low organic matter content and low total nitrogen and available phosphate [13].

2.2 Treatment and Experimental Design

The treatments consisted of three levels of Urea fertilizer 0, 40 and 80 kg/ha and three different times of Urea application: during planting, two weeks after planting, four weeks after planting and six weeks after planting. A factorial experiment laid in a Randomized Complete Block Design (RCBD) and replicated three times.

2.3 Soil Sample Collection

Soil samples were collected on the farm at a depth of 0-15 cm with soil auger before planting and bulked together to form a composite sample and take to the laboratory for analysis.

2.4 Laboratory Analysis of Soil

The soil sample collected was air-dried, and gently crushed, then passed through 2mm sieve to obtain a homogeneous particle size, after which standard laboratory procedures as described by Agbenin [14] was used for analysis of both physical and chemical properties.

2.5 Data Collected

Three plants were randomly tagged per plot and the following data on growth parameters collected: vine length, number of branches, number of leaves, fresh and dry herbage yield. Yield parameters: number of pods per plant; number of seeds per pod, weight of Hundred seeds, pod yield per hectare, seed yield per hectare and harvesting index were estimated in present study.

2.6 Agronomic Practice

Seed bed was well prepared by ploughing and harrowing and plots were marked out into 9 m² plot. Local variety of cowpea (Kananade) was planted together with the first application of nitrogen fertilizer at the spacing of 75 x 25 cm. Other nitrogen fertilizer applications were done based on the treatments design. Weeds were controlled through manual hoeing and subsequently by hand pulling when the cowpea started flowering.

2.7 Data Analysis

The data collected were subjected to analysis of variance using GENSTAT and where there is significant difference; the means were separated using F-LSD at 5% probability level.

3. RESULTS

3.1 Experimental Soil

The soil has high sandy particles (85.00 and 87.00) in both years of cropping, and was texturally classified as Sandy loam (Table 1). The soil was also low in nitrogen, phosphorus, potassium, organic carbon, organic matter, basic cations and cation exchange capacity. Also, the

soil was slightly acidic in nature (6.08, 6.01); but very high in base saturation (87.00 and 82.00) in both years.

3.2 Effect of Time of Application of Nitrogen Fertilizer on Growth Parameters of Cowpea

Nitrogen fertilizer rates and time of application had a significant increased on all the growth parameters of cowpea in 2017 and 2018 trials (Table 2). Application of 80kg N ha⁻¹ produced the highest number of cowpea leaves (134.45, 139.23), number of branches (9.45, 10.54), vine length (78.23 cm, 80.12 cm), fresh biomass weight (225.26 g, 231.34 g) and dry biomass weight (34.24 g, 35.89 g) in 2017 and 2018 cropping season respectively compare to other rates of nitrogen fertilizer at eight weeks after planting. Nitrogen fertilizer application and time of application significantly reduced number of root nodules. The control plot produced plants with the highest number of root nodules (14.78) in 2017 cropping and 12. 76 in 2018 cropping compare to other rates of nitrogen application. Also, application of nitrogen fertilizer 2 weeks after planting was superior in terms of increasing all the growth parameters than all other time of nitrogen fertilizer application to cowpea. However, the above result is statistically the same with application of nitrogen on the fourth week of cowpea planting. Application of nitrogen fertilizer during planting of cowpea recorded the highest number of root nodules (15.95 and 13.49) in both 2017 and 2018 cropping season respectively, while the lowest number of root

nodules (10.35 and 9.87) in both years of cropping were recorded in plots with nitrogen fertilizer applied on the 6 weeks after planting. However, interaction between nitrogen fertilizer rates and time of application did not showed any significant difference in all the growth parameters assessed throughout this study in both years.

3.3 Effect of Time of Application of Nitrogen Fertilizer on Yield Parameters of Cowpea

Nitrogen fertilizer rates and time of application had a significant (P < 0.05) increase in all the yield and yield components (No. of pods, weight of 100 seeds, pod weight/hectare, seeds weight/hectare) except the number of seeds per pod of cowpea at harvest in both years of trials (Table 3). Application of 80kg N ha⁻¹ recorded the highest seed weight of 0.52 t ha⁻¹ in both years of cropping cowpea compare to other rates of nitrogen application. The control plots in 2017 and 2018 trials recorded only 0.15 t ha⁻¹. Application of nitrogen fertilizer at two weeks after planting of cowpea produced the highest yield of 0.68 t ha⁻¹ of cowpea seeds in 2017 trial, while in 2018 trial, application of nitrogen fertilizer at two weeks after cowpea planting produced seed yield of 0.69 tha⁻¹ which is statistically similar with application of nitrogen fertilizer on the fourth week after planting which produced 0.55 t ha⁻¹ of cowpea seeds. The interaction between nitrogen fertilizer application rates and time of application did not showed any significant difference in cowpea yield and yield components in both years of cropping.

Table 1. Laboratory analysis of soils at 0-30 cm before cropping

Properties	2017	2018
Mech. composition		
Clay (%)	11.6	10.6
Silt	3.4	2.4
Sand	85.0	87.0
TCL (USD)	SL	SL
Chemical composition		
pH(H ₂ O)	6.08	6.01
pH(0.01MKCl ₂)	6.01	6.00
T N%	0.04	0.02
% OC	0.64	0.54
% O M	1.10	1.04
Avail. P(ppm)	4.57	3.27
K(mgkg ⁻¹)	0.31	0.63
Mg(cmolk ⁻¹)	1.78	1.05
Ca(cmolk ⁻¹)	3.41	3.12
Na(cmolk ⁻¹)	0.67	0.42
Al + H(acidity)	0.83	0.52
CEC(cmolk ⁻¹)	6.17	6.04
%Base Saturation	87.00	82.00

Table 2. Effect of time of application of nitrogen fertilizer on growth parameters of cowpea at eight WAP

Treatments	No. leaves per plant		No. branches per plant		Vines length (cm) per plant		Fresh biomass weight (g)/plant		Dry biomass weight (g)/plant		No. of roots nodules	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Urea (kg/ha)												
0	68.42	64.32	4.31	4.56	40.45	38.21	134.24	128.45	19.67	18.12	14.78	12.76
40	98.56	103.54	7.54	6.95	52.78	53.48	167.54	170.12	29.87	30.23	12.45	11.02
80	134.45	139.23	9.45	10.54	78.23	80.12	225.26	231.34	34.24	35.89	10.12	9.97
LSD(0.05)	10.34	9.58	1.24	1.05	8.12	12.24	20.25	21.78	12.05	10.24	1.12	1.01
Time of application												
At Sowing	75.45	69.45	4.78	4.84	42.26	43.08	145.26	141.78	20.45	19.56	15.95	13.49
2WAP	142.01	139.45	9.12	9.27	76.98	73.21	243.25	251.89	38.12	39.45	12.45	11.24
4WAP	132.12	140.46	7.98	8.12	68.02	69.56	214.14	222.34	33.21	35.19	12.78	10.15
6WAP	112.42	122.16	5.64	6.78	62.54	64.97	205.24	216.23	31.05	32.28	10.35	9.87
LSD(0.05)	11.45	10.58	1.72	1.04	2.45	2.12	12.45	10.45	2.04	1.45	1.14	1.02
Interaction												
Urea X Time of Application	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

WAP=Weeks after Planting; No Significant different

Table 3. Effect of time of application of nitrogen fertilizer on yield parameters of cowpea at harvest

Treatments	No. of pods per plant		No. of seeds per pod		Weight of 100 seeds (g)		Pod weight per Hectare (t/ha)		Seed yield per hectare (kg/ha)		Seed yield per hectare (t/ha)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Urea (kg/ha)												
0	15.00	15.98	6.74	7.08	20.34	21.45	0.36	0.32	151.00	150.03	0.15	0.15
40	22.14	21.71	7.09	7.09	25.45	24.24	0.66	0.67	363.56	372.06	0.36	0.37
80	27.75	28.68	7.08	7.08	27.25	28.12	1.10	1.14	522.57	523.98	0.52	0.52
LSD(0.05)	4.24	5.23	2.45	2.67	3.56	3.98	0.13	0.10	102.45	100.56	0.10	0.10
Time of application												
At Sowing	16.24	14.56	7.34	7.32	22.24	21.24	0.41	0.38	156.21	154.43	0.16	0.15
2WAP	35.32	34.78	7.25	7.43	29.19	28.78	1.18	1.19	683.24	691.49	0.68	0.69
4WAP	31.95	31.02	7.04	7.29	27.22	25.26	1.12	1.13	545.56	554.34	0.55	0.55
6WAP	29.02	28.20	7.12	7.32	25.23	22.27	0.98	1.01	427.42	428.23	0.43	0.43
LSD(0.05)	4.72	5.45	1.24	1.98	2.34	2.12	0.08	0.04	112.45	135.34	0.11	0.14
Interaction												
Urea X Time of Application.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

4. DISCUSSION

From the result of soil analysis (Table 1), it was clearly discovered that the soil was already nutrients depleted, exhausted and slightly acidic. This soil was already degraded; due to intensive and continuous cultivation and without adequate application of replenishment measures to sustain its productivity. This confirmed the earlier findings of Ndor et al. [15], who worked on the effect of soil nutrients dynamics as results of different maize based farming practices around the experimental site. The significant response of all the growth parameters of cowpea to application of nitrogen fertilizer may be attributed to initial state of the soil that was already low in nitrogen (Table 1). Therefore, application of nitrogen fertilizer immediately triggers this type of quick growth response. This result is in tandem with the earlier findings of Abayomi et al. [5]; but contradicts the report of [16] who worked on effect of NPK and pig manure on soil nutrients dynamics and production of cowpea. A reverse trend was discovered in number of root nodules; where increase application of nitrogen fertilizer brought about reduction in number of root nodules in both years of cropping. This corroborate the results of the works of Ofori [17] and Olatunji et al. [4] who observed that nodulation in cowpea was significantly reduced at higher rates of nitrogen fertilizer application. The above report may also confirmed the reason why in this study, root nodules were higher when nitrogen fertilizer was applied during the planting of cowpea. Therefore, before cowpea could germinate and form roots nodules the effect of nitrogen fertilizer was gone; since nitrogen is known to be one of the highly mobile element in the soil [18]. The significant improvement in the yield of cowpea in this study may be attributed to the better growth parameters obtained as a result of nitrogen fertilizer application which increased numbers of leaves, branches and vine length (Table 2). This finding is in consonance with the result earlier reported by Abayomi et al. [5] and Omotoso [16]. Also, Dugje et al. [19] reported a significant effect of N fertilization on yield of cowpea across many ecological zones of West Africa. However, this result above contradicts the recent findings of [8] who reported no significant effect of nitrogen fertilizer on the yield of cowpea; and therefore recommended that there is no need of nitrogen fertilizer application for cowpea production. The significant performances display in terms of yield as a result of application of nitrogen fertilizer at two weeks after planting may be attributed to the fact that nitrogen fertilizer

was applied to cowpea at an earlier age before the onset of symbiotic nitrogen fixation; when cotyledonary nitrogen reserves are exhausted. Sarr et al. [9] have shown that plants given inorganic nitrogen during early vegetative growth were much larger by the onset of flowering compared to those depending on symbiotic nitrogen fixation alone and such plants also produced more branches and peduncles resulting in greater number of pods, seeds and significantly ($P < 0.05$) higher yields. Bationo and Ntare [20], also reported that the application of starter N fertilizer gives cowpea seedlings a good start, enhances early vegetative growth which results in increased branches, higher number of pods, seeds, and grain yield.

5. CONCLUSION

From this study, it can be concluded that application of 80kg N ha^{-1} was the recommended nitrogen fertilizer rate and time of application of this nitrogen fertilizer should be two weeks after planting.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

The peer review history for this paper can be accessed here:

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